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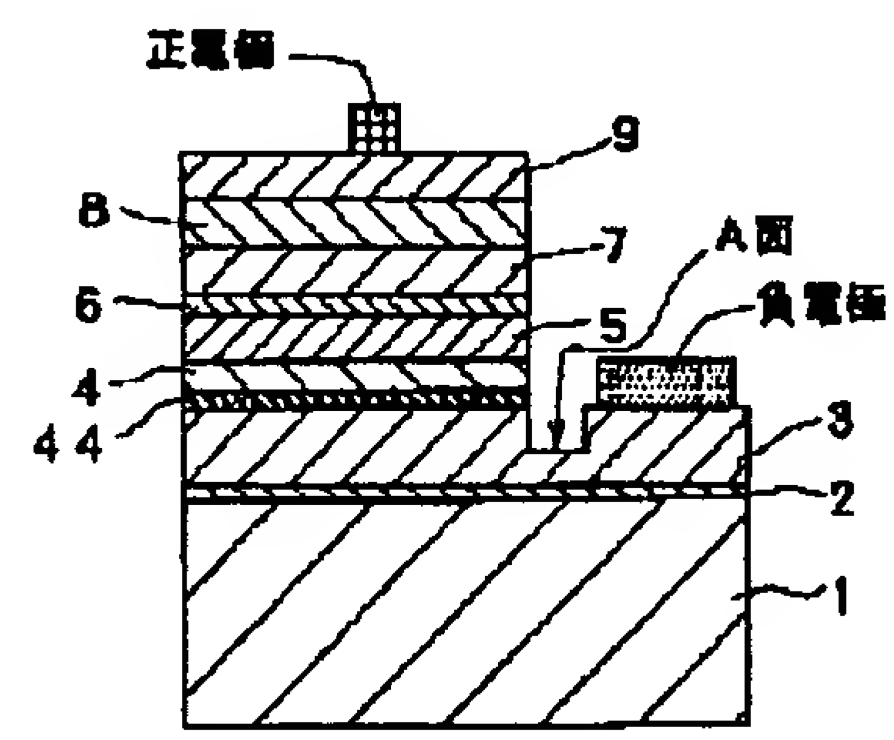
(54) NITRIDE SEMICONDUCTOR LASER DEVICE

(57) Abstract:

PURPOSE: To provide a laser device using nitride semiconductor, and particularly a short wavelength laser which oscillates in ultraviolet to green regions.

CONSTITUTION: In a nitride semiconductor laser device, at least a first n-type clad layer 5 made of n-type nitride semiconductor, an active layer 6 made of nitride semiconductor containing indium and gallium in contact with the first clad layer, and a first p-type clad layer 7 made of p-type nitride semiconductor in contact with the active layer are sequentially stacked on a substrate 1. The side of the p-type nitride semiconductor is etched so that a pair of positive and negative electrodes are taken out to the same side. On the outside of the first n-type clad layer 5, an n-type multilayer film 44 composed of stacked two types of nitride semiconductor layers having different compositions is provided as a light reflection film. The n-type multilayer film is formed at a position closer to the p-type nitride semiconductor layer than the etching surface (surface A) which is closest to the substrate.



[Claim(s)]

[Claim 1] The first cladding layer which consists of an n mold nitride semi-conductor at least on a substrate, The barrier layer which consists of a nitride semi-conductor which contains an indium and a gallium in contact with the first cladding layer, It has the structure where the laminating of the first p mold cladding layer which consists of a p mold nitride semi-conductor in contact with the barrier layer was carried out to order. It is a nitride semiconductor laser component equipped with the structure where it was furthermore etched from p mold nitride semi-conductor side, and the electrode of forward and a negative pair was taken out at the same side side. Two kinds of nitride semi-conductor layers from which a presentation differs mutually on the outside of said first n mold cladding layer are equipped with the multilayers of n mold which comes to carry out a laminating as light reflex film. Further the n type of multilayers The nitride semiconductor laser component characterized by being formed in the location near [horizontal plane / of the etching side nearest to a substrate side] p mold nitride semi-conductor layer.

[Claim 2] The nitride semiconductor laser component according to claim 1 characterized by equipping two kinds of nitride semi-conductor layers from which a presentation differs mutually on the outside of said first p mold cladding layer with the multilayers of p mold which comes to carry out a laminating as light reflex film.

[Claim 3] The nitride semi-conductor light emitting device according to claim 1 or 2 characterized by either said first n mold cladding layer or said first p mold cladding layer, and both being the nitride semi-conductor layers or GaN layers containing an indium and a gallium.

[Claim 4] [whether second n mold cladding layer which consists of an n mold nitride semi-conductor layer which contains aluminum and a gallium in contact with the outside of said first n mold cladding layer is formed, and] Or a nitride semiconductor laser component given in any 1 term of claim 1 characterized by forming second p mold cladding layer which consists of a p mold nitride semi-conductor which contains aluminum and a gallium in contact with the outside of said first p mold cladding layer thru/or the claims 3.

[Claim 5] A nitride semiconductor laser component given in any 1 term of claim 1 characterized by forming n mold contact layer which consists of an n mold GaN in contact with said first n mold cladding layer or said second n mold cladding layer, and forming p mold contact layer which consists of a p mold GaN in contact with said first p mold cladding layer or second p mold cladding layer further thru/or the claims 4.

[Claim 6] Said n type of multilayers are nitride semiconductor laser components given in any 1 term of claim 1 characterized by being formed in one of any places between first n mold cladding layer and second n mold cladding layer, between second n mold cladding layer and n mold contact layers, or inside n mold contact layer, claim 3, claim 4, or the claims 5.

[Claim 7] Said p type of multilayers are nitride semiconductor laser components given in any 1 term of claim 2 characterized by being formed in one of any places between first p mold cladding layer and second p mold cladding layer, between second p mold cladding layer and p mold contact layers, or inside p mold contact layer, claim 3, claim 4, or the claims 5.

[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to the laser component which consists of a nitride semi-conductor (Ina'Alb'Ga1-a -- '-b'N, 0<=a', 0<=b', a' -- +b'<=1).

[0002]

[Description of the Prior Art] the nitride semi-conductor (Ina'Alb'Ga1-a -- '-b'N, 0<=a', 0<=b', a' -- +b'<=1) is known as an ingredient of the laser component which can be oscillated in ultraviolet - red. Using this semiconductor material, we announced blue LED with a luminous intensity of 1 cd in November, 1993, announced the bluish green color LED with a luminous intensity of 2 cds in April, 1994, and announced blue LED with a luminous intensity of 2 cds in October, 1994. All of such LED are produced commercially and practical use of a current display, a signal, etc. is presented with it.

[0003] The structure of the luminescence chip of the present blue and the bluish green color LED is shown in drawing 1 . It has the structure where the laminating of n mold

contact layer 12 which consists of an n mold GaN on silicon on sapphire 11 fundamentally, n mold cladding layer 13 which consists of an n mold AlGaN, the barrier layer 14 which consists of an n mold InGaN, p mold cladding layer 15 which consists of a p mold AlGaN, and the p mold contact layer 16 which consists of a p mold GaN was carried out to order. In addition, although the buffer layer which consists of GaN, AlGaN, or AlN is formed between silicon on sapphire 11 and n mold contact layer 12, it is not illustrating especially in this drawing. p mold dopants, such as n mold dopants, such as Si, germanium, and S, and/or Zn, Mg, are doped, the luminescence wavelength of an LED component is changing the class of impurity which changes In presentation ratio of InGaN of the barrier layer, or is doped to a barrier layer, and, as for the n mold InGaN of a barrier layer 14, it is possible to make it change to ultraviolet - red.

[0004]

[Problem(s) to be Solved by the Invention] Thus, current [by which LED which emits light with terrorism structure to double was realized], and the next technical problem are in implementation of the short-wavelength-laser component which used the ******** semi-conductor. It has still come [however,] to carry out laser oscillation of the nitride semi-conductor.

[0005] Therefore, this invention is accomplished in order to solve the technical problem, and the place made into the purpose is to realize the laser component which used the nitride semi-conductor, and is to realize short wavelength laser oscillated especially in an ultraviolet - green field.

[0006]

[Means for Solving the Problem] We formed the light reflex film which has luminescence of a barrier layer shut up by the position in the nitride semi-conductor by which the laminating was carried out so that it might become terrorism structure to double in the first place first, by second improving the crystallinity of a barrier layer, find out newly that the above-mentioned problem is solvable, and came to accomplish this invention. Namely, the first cladding layer to which the nitride semiconductor laser component of this invention consists of an n mold nitride semi-conductor on a substrate, The barrier layer which consists of a nitride semi-conductor which contains an indium and a gallium in contact

with the first cladding layer, It has the structure where the laminating of the first p mold cladding layer which consists of a p mold nitride semi-conductor in contact with the barrier layer was carried out to order. It is a nitride semiconductor laser component equipped with the structure where it was furthermore etched from p mold nitride semi-conductor layer side, and the electrode of forward and a negative pair was taken out at the same side side. Two kinds of nitride semi-conductor layers from which a presentation differs mutually on the outside of said first n mold cladding layer are equipped with the multilayers of n mold which comes to carry out a laminating as light reflex film. Further the n type of multilayers It is characterized by being formed in the location near [horizontal plane / of the etching side nearest to a substrate side] p mold nitride semi-conductor layer. However, an outside does not need to mean the opposite side of a cladding layer in which the barrier layer is formed, and it does not necessarily need to be in contact with a cladding layer.

[0007] Moreover, it is characterized by equipping the second of this invention with the multilayers of p mold with which it comes to carry out the laminating of two kinds of p mold nitride semi-conductor layers from which a presentation differs mutually on the outside of said first p mold cladding layer as light reflex film.

[0008] The typical sectional view showing the structure of the laser component concerning one example of this invention is shown in <u>drawing 2</u> . The buffer layer to which 1 eases silicon on sapphire and 2 eases the stacking fault number of a substrate and a nitride semi-conductor layer, n mold contact layer in which 3 forms the negative electrode, and 4 show second n mold cladding layer and p mold contact layer in which in first n mold cladding layer and 6 first p mold cladding layer and 8 form second p mold cladding layer in, and, as for 9, a barrier layer and 7 form [5] a positive electrode, respectively. In this drawing, n mold multilayers 44 which reflect the light of a barrier layer 6 between first n mold cladding layer 5 and second n mold cladding layer 4 are formed so that luminescence from a barrier layer 6 furthermore may not spread in a substrate 1 side. And the formation location of n mold multilayers 44 is formed in the location near [horizontal plane / (in <u>drawing 2</u> , it is considering as the horizontal plane of the etching side of n mold contact layer 3 in which the negative electrode is formed.) / of the etching side nearest to a substrate 1 side] p mold nitride semi-conductor layer. n mold multilayers 44 have the

operation which the laminating of the nitride semi-conductor with which presentations differ mutually, i.e., two kinds of nitride semi-conductors with which refractive indexes differ mutually, is carried out more than two-layer by turns by lambda/4n (lambda: wavelength, n:refractive index), they reflect the luminescence wavelength of a barrier layer 6 by n mold multilayers 44, and is shut up into a barrier layer 6.

[0009] Moreover, drawing 3 is the typical sectional view showing the structure of the laser component concerning other examples of this invention, and the same sign shows the same member as drawing 2 . In drawing 3 , n mold multilayers 44 are formed between n mold contact layer 3 and second n mold cladding layer 4, and the multilayers 55 of p mold which carried out the laminating of two kinds of nitride semi-conductors with which presentations differ mutually between second p mold cladding layer 8 and p mold contact layer 9 by turns are formed. If the multilayers 55 of p mold which serves as light reflex film like drawing 3 are formed also into p type layer, since slight optical closing depth of a barrier layer will be made still more efficiently than the time of forming n mold multilayers 44 into n type layer, it becomes easy to carry out laser oscillation easily. Moreover, it is formed in the location with drawing 3 similarly near [horizontal plane /, i.e. the horizontal plane of the etching side nearest to a substrate 1 side, / the horizontal plane of the etching side of n mold contact layer 3 in which the negative electrode is formed / the formation location of n mold multilayers 44] p type layer side.

[0010] Moreover, drawing 4 is the typical sectional view showing the structure of the laser component concerning other examples of this invention, and the same sign shows the same member as drawing 2 and drawing 3 . In drawing 4 , n mold multilayers 44 are formed between first n mold cladding layer 5 and second n mold cladding layer 4, and the multilayers layer 55 of p mold is formed between first p mold cladding layer 7 and second p mold cladding layer 8.

[0011] Moreover, although it is the typical sectional view showing the structure of the laser component which drawing 6 also requires for other examples of this application, the point that this drawing differs from the structure of the laser component of other this inventions makes etching from a p layer side deep, and the depth of p mold contact layer of the horizontal plane of an etching side is just going to be in a substrate side rather than the

forming face of the negative electrode. The location of n mold multilayers 44 shows that it is formed in the location near [horizontal plane / (Ath page) / of the etching side nearest to a substrate side] p mold nitride semi-conductor layer. An operation of the location of n mold multilayers 44 is described in detail later.

[0012] The multilayers 44 of n mold Thus, between first n mold cladding layer 5 and second n mold cladding layer 4, Between second n mold cladding layer 4 and n mold contact layers 3 or the interior of n mold contact layer (an example explains the interior.) In being able to form in any one place and forming p mold multilayers 55 It can form in one of any places between second p mold cladding layer 8 and p mold contact layer 9 or inside p mold contact layer like the publication also to claim 7 between first p mold cladding layer 7 and second p mold cladding layer 8.

[0013] Next, as for two kinds of nitride semi-conductors which constitute said n mold multilayers 44 and p mold multilayers 55, it is desirable that they are the nitride semi-conductor with which at least one side contains an indium and a gallium, or GaN {for example, IncGa1-cN (0<=c<1)}. because, the case where carry out the laminating of the monolayer and it considers as multilayers -- one side of the monolayer -- IncGa1- it is because it can prevent that GaN and an IncGa1-cN layer carry out an operation like a buffer layer, and a crack goes into another monolayer by forming cN and GaN. The crystal of an IncGa1-cN layer and a GaN layer depends this on a soft thing compared with AlGaN. On the other hand, if it is the AlGaN layer from which aluminum presentation differs mutually, for example, for example, multilayer formation of the multilayers is carried out so that it may become the 0.5 micrometers or more of the total thickness, a crack will enter into multilayers and component production will become difficult.

[0014] It is best that one side constitutes a desirable combination of two kinds of nitride semi-conductors which constitute multilayers from a nitride semi-conductor {for example, AldGa1-dN (0< d<1)} with which another side contains aluminum and a gallium by consisting of IncGa1-cN or GaN as mentioned above. IncGa1-cN and AldGa1-dN are because the difference of a refractive index is large, so the design of multilayers with a large reflection factor is possible by constituting multilayers from these ingredients according to luminescence wavelength. Moreover, since IncGa1-cN is carrying out the

operation of a buffer layer, a ten or more layer laminating becomes possible, without a crack going into another AldGa1-dN layer. In addition, the refractive indexes of InN, GaN, and AlN are 2.9, 2.5, and 2.15, respectively. The refractive index of such mixed crystal assumes that Vegard's Law is followed, and it can ask for it under the condition that it is proportional to a presentation.

[0015] Here, adjusting to 0.2 or less is [0.5 or less / 0.3 or less] preferably desirable [c value of IncGa1-cN] most preferably. It is because the crystallinity of InGaN worsens as the mole ratio of an indium becomes large. Moreover, as for d value of AldGa1-dN, carrying out to 0.4 or less is [0.6 or less] still more preferably desirable. It is because it will be easy to generate a crack in an AlGaN layer if larger than 0.6.

[0016] Next, in order to realize a laser component, the component structure where the barrier layer excellent in crystallinity is obtained is explained based on a drawing.

[0017] Although any are sufficient p molds, a barrier layer 6 {for example, InXGa1-XN (0< X<1)} is desirable, especially when strong luminescence between bands is obtained, the half-value width of luminescence wavelength becomes narrow and a laser component is realized n mold and by considering especially as a non dope (additive-free). Especially, preferably, if a barrier layer considers as single quantum well (SQW:single quantum well) structure or multiplex quantum well (MQW:multi quantum well) structure, a light emitting device with a very high output will be obtained. It is the layer which pointed out the structure of a barrier layer where luminescence between the quantum level by InGaN of a non dope was obtained, in SQW and MQW, for example, constituted the barrier layer from InXGa1-XN (0<=X<1) of a single presentation at SQW, and strong luminescence between quantum level is obtained by making still more preferably 100A or less of thickness of InXGa1-XN into 70A or less. Moreover, MQW is taken as the multilayers which carried out two or more laminatings of the thin film of InXGa1-XN (X= 0 and X= 1 are included in this case) with which presentation ratios differ. Thus, luminescence to about 365nm - 660nm is obtained by luminescence between quantum level by setting a barrier layer to SQW and MQW. As thickness of the well layer of quantum structure, 70A or less is desirable as mentioned above. Multiplex quantum well structure constitutes a well layer from InXGa1-XN, and, as for a barrier layer, it is desirable to constitute by InYGa1-YN

(for Y= 0 to be included in Y<X and this case) similarly. Since it can grow up at the same temperature if a well layer and a barrier layer are especially formed by InGaN preferably, a crystalline good barrier layer is obtained. If 150A or less of thickness of a barrier layer is made into 120A or less still more preferably, a high power light emitting device will be obtained. Moreover, n mold dopant and/or p mold dopant may be doped to a barrier layer 6. If n mold dopant is doped, compared with the thing of a non dope, bands luminescence reinforcement can be strengthened further. Although peak wavelength can be brought to about 0.5eV low energy side rather than the peak wavelength of luminescence between bands if p mold dopant is doped, half-value width is in the inclination to become large and for laser oscillation to become difficult. Moreover, since half-value width is large too although luminescence reinforcement of the barrier layer which doped only p mold dopant mentioned above can be enlarged further when p mold dopant and n mold dopant are doped to coincidence, it is in the inclination for laser oscillation to become difficult. In order to grow up a crystalline good barrier layer and to consider as a laser component, it is most desirable to consider as single quantum well structure or multiplex quantum well structure with a non dope as mentioned above.

[0018] A barrier layer 6 needs to be inserted by the cladding layer with a surely larger band gap than a barrier layer 6. In drawing 2 , in contact with a first [of a barrier layer 6] principal plane side, first n mold cladding layer 5 is formed, and first p mold cladding layer 7 is formed in contact with a second [of a barrier layer 6] principal plane side. Although what kind of presentation is sufficient as long as the semiconductor material of first n mold cladding layer 5 and second p mold cladding layer 7 is a nitride semi-conductor with a larger band gap than a barrier layer, preferably especially the nitride semi-conductor which contains an indium and a gallium for first n mold cladding layer 5, or GaN -- {-- for example It forms by n mold InYGa1-YN(0<=Y<1)}, and first p mold cladding layer 7 is formed by the nitride semi-conductor which similarly contains an indium and a gallium, or GaN {for example, n mold InZGa1-ZN (0<=Z<1)}. However, when forming first n mold cladding layer 5 and first p mold cladding layer by InGaN, it is also possible to omit one of cladding layers, but as especially shown in drawing 2 preferably, it forms in both sides of a barrier layer 6. Since first n mold cladding layer 5 containing an indium and second p mold

cladding layer 7 are soft, a crystal These cladding layers carry out an operation of a buffer layer like a cushion. When second n mold cladding layer 4, second p mold cladding layer 8, n mold contact layer 3, and p mold contact layer 9 grade are formed in the outside of these cladding layers, it can prevent that a crack enters into these layers (3, 4, 8, 9). As for the desirable range of the thickness of the InGaN cladding layer which acts as a buffer layer, in the combination of a barrier layer 6, first n mold cladding layer 5 and a barrier layer 6, first p mold cladding layer 7 and first n mold cladding layer 5, a barrier layer 6, and first p mold cladding layer 7, it is desirable to make the total thickness of the combined InGaN layer into 300A or more. Moreover, if first n mold cladding layer 5 is omitted when it considers as a laser component, second n mold cladding layer 4 will act as first n mold cladding layer 5, and if first p mold cladding layer 7 is omitted, similarly second p mold cladding layer 8 will act as first p mold cladding layer 7.

[0019] As mentioned above, adjusting to 0.2 or less is [0.5 or less / 0.3 or less] preferably desirable [In presentation ratio of these InGaN(s), i.e., X value, Y value, and Z value], although first n mold cladding layer 5 which consists of InGaN, a barrier layer 6, and first p mold cladding layer 7 were explained most preferably. It is because it is in the inclination for the crystallinity of InGaN to worsen and for a radiant power output to decline as the mole ratio of an indium becomes large. Furthermore, InAlGaN which permuted a part of Ga with aluminum of a minute amount in the range which does not change the effectiveness of InGaN into the formula shall also be contained in said formula in said InXGa1-XN, InYGa1-YN, and InZGa1-ZN. for example, the inside of an Ina'Alb'Ga1-a'-b'N type -- b' -- with [a value] 0.1 [or less], the effectiveness of first n mold cladding layer, a barrier layer, and second p mold cladding layer does not change However, since it is in the inclination for a crystal to become hard when aluminum is made to contain, it becomes easy to carry out laser oscillation of constituting a barrier layer 6, first n mold cladding layer 5, and first p mold cladding layer 7 only from InGaN of 3 yuan mixed crystal which does not contain aluminum, and is the best than the nitride semi-conductor of 4 yuan mixed crystal.

[0020] Next, second n mold cladding layer 4 formed in contact with the outside of first n mold cladding layer 5 It is desirable to form with n mold nitride semi-conductor {for

example, n mold AlaGa1-aN (0< a<1)} containing aluminum and a gallium. Moreover, as for second p mold cladding layer formed in contact with the outside of first p mold cladding layer 7, it is desirable to form with the nitride semi-conductor {for example, p mold AlbGa1-bN (0< b<1)} which similarly contains aluminum and a gallium. Here, when forming second n mold cladding layer 4 and second p mold cladding layer 7 by AlGaN, it is also possible to omit one of cladding layers, but as especially shown in drawing 2 preferably, while forming second n mold cladding layer 4 in contact with first n mold cladding layer 3, in contact with first p mold cladding layer 7, second p mold cladding layer 8 is both formed. However, if second n mold cladding layer 4 and first n mold cladding layer 5 are omitted to coincidence and first p mold cladding layer 7 and second p mold cladding layer 8 are omitted to coincidence, it is difficult to carry out laser oscillation.

[0021] Moreover, as for second n mold cladding layer 4 and second p mold cladding layer 8, it is desirable to form by 10A - 0.5 micrometers thickness. As for aluminum mixed-crystal ratio of AlGaN, i.e., a value, and b value, carrying out to 0.4 or less is [0.6 or less] still more desirable still more preferably. It is because it will be easy to generate a crack in an AlGaN layer if the crystal of AlGaN is hard and is larger than 0.6. If this is larger than 0.6 even if the buffer layer by said InGaN acts, a crack will extremely become easy to generate it.

[0022] Moreover, InAlGaN which permuted a part of Ga by In of a minute amount in the range which does not change the effectiveness of AlGaN into the formula shall also be contained in said formula in said AlaGa1-aN and AlbGa1-bN. for example, the inside of an Ina'Alb'Ga1-a'-b'N type -- a' -- with [a value] 0.1 [or less], the effectiveness of AlGaN hardly changes However, since a band gap will become small if In of a minute amount is made to contain, a band gap must be made larger than first n mold cladding layer 5, a barrier layer 6, and second p mold cladding layer 7. Moreover, since it is in the inclination for crystallinity to worsen and for a radiant power output to decline when In is made to contain, a radiant power output becomes large and it is most desirable than the nitride semi-conductor of 4 yuan mixed crystal to constitute second n mold cladding layer 4 and second p mold cladding layer 8 only from AlGaN of 3 yuan mixed crystal which does not contain In. Thus, by making the layer containing aluminum into second n mold cladding

layer 4 and said second p mold cladding layer 8, since band offset with a barrier layer 6, first n mold cladding layer 5, and first p mold cladding layer 7 can be enlarged, luminous efficiency can be gathered.

[0023] A desirable combination of a barrier layer 6 and the first cladding layer 5 and 7 is that form first n mold cladding layer by InYGa1-YN, and it forms InXGa1-XN and first p mold cladding layer for a barrier layer by InZGa1-ZN. However, in said combination, it cannot be overemphasized that Y<X and Z<X are filled from the relation of a band gap. Since narrow luminescence of the half-value width according [the direction of n mold or a non dope] to luminescence between bands is obtained, a barrier layer is desirable.

[0024] As further most desirable combination, it recommends forming AlaGa1-aN and first n mold cladding layer by InYGa1-YN, and forming [second n mold cladding layer / a barrier layer] InZGa1-ZN and second p mold cladding layer for InXGa1-XN and first p mold cladding layer by AlbGa1-bN. According to this combination, it becomes terrorism structure to the double which carried out the laminating of the nitride semi-conductor which was most excellent in crystallinity, and laser oscillation becomes possible.

[0025] Next, n mold contact layer 3 is best to form n mold contact layer 3 in contact with second n mold cladding layer 4, and to form p mold contact layer 9 in contact with second p mold cladding layer 8, as desirably shown in drawing 2 R> 2. Moreover, n mold contact layer 3 can be formed in either second n mold cladding layer 4 or first n mold cladding layer 5, and can form p mold contact layer 9 in either second p mold cladding layer 8 or first p mold cladding layer 7. That is, if second n mold cladding layer 4 is omitted, it can form in contact with first n mold cladding layer 5, and if p mold contact layer 9 omits second p mold cladding layer 8 similarly, it can form in contact with first p mold cladding layer 7.

[0026] It is necessary to set the semi-conductor of n mold contact layer 3 and p mold contact layer 9 to GaN which does not contain aluminum and In further again. Since a contact layer is a layer which forms an electrode, if crystallinity is good and forms a layer with large carrier concentration, an electrode material and OMIKKU will become is easy to be obtained. For that purpose, GaN is the most desirable. Moreover, the metal which contains Ti and aluminum as an electrode material with which n mold contact layer 3 and

OMIKKU are easy to be obtained is desirable, and the metal which contains nickel and Au in the electrode material from which p mold contact layer 9 and OMIKKU are easy to be obtained is desirable. Thus, if the contact layer which considers as the layer which should form an electrode and consists of GaN is formed, laser oscillation will become possible on a low threshold electrical potential difference.

[0027] Next, if the concrete structure of the laser component of this invention is mentioned, as gain guided wave mold stripe mold laser, an electrode stripe mold, a mesa stripe mold, a hetero isolation mold, etc. can be mentioned. Moreover, in addition to this, an embedding hetero mold, a CSP mold, a rib guide mold, etc. can be mentioned as stripe mold laser with a fixture guided wave device. An electrode with a width of face of several micrometers to about 20 micrometers is usually formed in the laser component of such structures as waveguide at the maximum upper layer, and an oscillation is made to cause along with this stripe. The dielectric multilayers used as the optical resonance side for oscillating are formed in the nitride semi-conductor layer front face of a direction perpendicular to this stripe.

[0028] In the above, although the structure of a laser component was explained, the manufacture approach is explained briefly below. In order to manufacture the laser component which consists of a nitride semi-conductor, it is obtained by carrying out a laminating using vapor growth, such as MOVPE (metal-organic chemical vapor deposition), MBE (molecular-beam vapor growth), and HDVPE (hydride vapor growth), so that it may become terrorism structure to double with conductivity types, such as n mold and p mold, about $In_{a'}Al_{b'}Ga_{1-a'-b'}N$ ($0<=a'$, $0<=b'$, $a'+b'<=1$) on a substrate. Sapphire (C side, the Ath page, and the Rth page are included), SiC (6 H-SiC and 4 H-SiC are also included), ZnO and Si, GaAs, a spinel, etc. can be used for a substrate 1, and drawing 2 shows silicon on sapphire. Although the nitride semi-conductor of n mold is obtained also in the state of a non dope, it is obtained by introducing n mold dopants, such as Si, germanium, and S, into a semi-conductor layer into crystal growth. Moreover, the nitride semi-conductor layer of p mold is obtained by introducing p mold dopants, such as Mg, Zn, Cd, calcium, Be, and C, into a semi-conductor layer into crystal growth similarly, or performing annealing above 400 degrees C after installation. A buffer layer 2 is formed in

order to ease the stacking fault number of a substrate 1 and a nitride semi-conductor, for example, in the MOVPE method, GaN, AlN, GaAlN, etc. are formed at the low temperature around 500 degrees C in many cases. Moreover, a buffer layer may not be formed in case a substrate with near nitride semi-conductor like SiC and ZnO and lattice constant is used.

[0029]

[Function] When a laser component was conventionally realized using a nitride semi-conductor, slight optical closing depth to a barrier layer was performed by reflection of the refractive-index difference of a cladding layer and a barrier layer. However, there are very few refractive-index differences and they are at most 0.5 or less. For this reason, almost all light will penetrate a cladding layer and will spread. Although the light which penetrated p mold cladding layer and spread finally appears in an air space, the refractive index of air is 1 and the refractive index of p mold contact layer GaN is 2.5. A refractive-index difference here is large, since it is reflected and a remarkable light returns to a barrier layer side, light shuts it up and its effectiveness is large. It can say that the same is said of the horizontal direction of a semi-conductor layer. However, the light which penetrated n mold cladding layer has the small refractive index of n mold cladding layer and n mold contact layer, and since it is spread easily and goes into n mold contact layer, without being reflected by the interface, there is little effectiveness in slight optical closing depth. Therefore, luminescence of a barrier layer leaked to the substrate side, and laser oscillation did not happen.

[0030] On the other hand, in this invention, since the multilayers which carry out a light reflex are formed with the nitride semi-conductor into n type layer by the side of a substrate rather than the barrier layer, it becomes possible to reflect luminescence of a barrier layer in a barrier layer side, and to shut up in a barrier layer. If the reflection factor of multilayers controls thickness, for example, stacks it five or more pairs, it becomes about 80% - 99%, a very high reflection factor is obtained, and a very large thing is [a reflection factor] effective in the slight optical closing depth to a barrier layer. For this reason, it cannot be overemphasized that effectiveness becomes [the direction which inserted multilayers also in the p layer side above a barrier layer] large in slight optical

closing depth.

[0031] And this invention is the so-called flip chip method taken out from the same side side with the electrode of forward and a negative pair. In this case, it is necessary to form in the location near [horizontal plane / of the etching side nearest to a substrate side] p mold nitride semi-conductor layer n mold multilayers 44 formed in n type layer side as shown in drawing 2 , drawing 3 , drawing 4 , and drawing 6 . It is because the refractive-index difference of second n mold cladding layer 4 and n mold contact layer 3 is small when n mold multilayers 44 are formed in a substrate 1 side rather than the horizontal plane of the etching side nearest to a substrate side, so luminescence of a barrier layer 6 spreads in n mold contact layer 3 below a barrier layer 6 and slight optical closing depth is not made. Conversely, if n mold multilayers are formed in a location higher than the etching side nearest to a substrate side, i.e., the location near p type layer, it will not be spread in n mold contact layer, but almost all light will be reflected in a barrier layer, and light will be closed, and will become possible in slight depth. This is an operation peculiar to the nitride semiconductor laser of the flip chip method which takes out forward [from] and a negative electrode the same side side.

[0032] Next, especially the structure of the laser component of desirable this invention is described. The LED component of the conventional nitride semi-conductor had the structure which sandwiched the barrier layer which consists of InGaN by the cladding layer which consists of AlGaN. On the other hand, in this invention, by inserting the barrier layer which consists of this InGaN by InGaN with a larger band gap than that barrier layer, the radiant power output improved by leaps and bounds, and it found out that laser oscillation became possible. This is because a new InGaN cladding layer is working as a buffer layer between an InGaN luminous layer and an AlGaN cladding layer. the property in which InGaN is soft as a property of a crystal -- having -- **** -- the lattice constant of an AlGaN cladding layer and InGaN -- it is thought that there is work which absorbs the crystal defect produced according to a coefficient-of-thermal-expansion difference as it is irregular. For this reason, since the newly formed InGaN cladding layer absorbs these crystal defects and the crystal defect of an InGaN luminous layer decreases sharply, the crystallinity of an InGaN luminous layer becomes good by leaps and bounds,

and the laser oscillation of it becomes possible in ordinary temperature.

[0033] On the other hand, with the structure which sandwiched the AlGaN cladding layer for the conventional InGaN luminous layer, if thickness of an InGaN luminous layer is made into less than 200A, for example, many cracks will arise in an AlGaN cladding layer and an InGaN luminous layer. The AlGaN cladding layer has the very hard property on the property of a crystal, and, as for this, shows that the grid mismatching produced from an interface with an AlGaN cladding layer only in the InGaN luminous layer of thin thickness and distortion produced from a coefficient-of-thermal-expansion difference cannot be elastically eased by the InGaN luminous layer. For this reason, since a crack arises in an InGaN luminous layer and an AlGaN cladding layer and many crystal defects arise in a luminous layer, large improvement in an output cannot be desired.

[0034]

[Example] This invention is explained based on a concrete example below. The following examples show the growth approach by the MOVPE method.

[0035] An example 1 is explained based on [example 1] drawing 2 . The buffer layer 2 which becomes C side of the silicon on sapphire 1 first set to the reaction container using TMG (trimethylgallium) and NH3 from GaN at 500 degrees C is grown up by 500A thickness.

[0036] Next, temperature is raised to 1050 degrees C and TMG and n mold contact layer 3 which consists of an Si dope n mold GaN using SiH4 gas in addition to NH3 are grown up by 4-micrometer thickness.

[0037] Then, TMA (trimethylaluminum) is added to material gas and second n mold cladding layer 4 which similarly consists of an Si dope n mold aluminum0.3Ga0.7N layer at 1050 degrees C is grown up by 0.1-micrometer thickness.

[0038] Next, temperature is lowered to 800 degrees C, TMG, TMI (trimethylindium), NH3, and SiH4 are used for material gas, and the thin film which consists of Si dope n mold In0.01Ga0.95N is grown up by 380A thickness. Then, the thin film which raises temperature to 1050 degrees C and consists of Si dope n mold aluminum0.2Ga0.9N using TMG, TMA (trimethylaluminum), NH3, and SiH4 is grown up by 390A thickness. And these actuation is repeated 20 times and n mold multilayers 44 which carried out ten layers

at a time the laminating of an Si dope n mold In0.01Ga0.95N layer and the Si dope aluminum0.2Ga0.9N layer by turns are formed.

[0039] Next, temperature is lowered to 800 degrees C and first n mold cladding layer 5 which consists of Si dope n mold In0.01Ga0.99N is grown up by 500A thickness using TMG, TMI (trimethylindium), NH3, and SiH4.

[0040] Then, the barrier layer 6 which consists of non dope In0.05Ga0.95N at 800 degrees C using TMG, TMI, and NH3 is grown up by 30A thickness.

[0041] Then, first p mold cladding layer 7 which newly consists of Mg dope p mold In0.01Ga0.99N at 800 degrees C using Cp2Mg (magnesium cyclopentadienyl) in addition to TMG, TMI, and NH3 is grown up by 500A thickness.

[0042] Next, temperature is raised to 1050 degrees C and second p mold cladding layer 8 which consists of Mg dope p mold aluminum0.3Ga0.7N is grown up by 0.1-micrometer thickness using TMG, TMA, NH3, and Cp2Mg.

[0043] Then, p mold contact layer 9 which consists of a Mg dope p mold GaN using TMG, NH3, and Cp2Mg at 1050 degrees C is grown up by 0.5-micrometer thickness.

[0044] After reaction termination, temperature is lowered to a room temperature, a wafer is picked out from a reaction container, annealing of a wafer is performed at 700 degrees C, and p type layer is further formed into low resistance. Next, the mask of a predetermined configuration is formed in the front face of p mold contact layer 9 of the maximum upper layer, and it etches until the front face of n mold contact layer 3 is exposed.

[0045] Next, the negative electrode which contains Ti and aluminum in n mold contact layer 3 by width of face of 50 micrometers, and the positive electrode which contains nickel and Au in p mold contact layer 9 by width of face of 10 micrometers are formed, respectively. Thus, if n mold multilayers 44 are formed in the front face of second n mold cladding layer 4, since it will etch to n mold contact layer 3, the horizontal plane which forms the negative electrode automatically becomes a substrate side so that it may be shown in under from n mold multilayers 44, i.e., drawing 2 .

[0046] Next, the silicon-on-sapphire side of the direction which does not form the nitride semi-conductor layer was ground, thickness of a substrate was set to 90 micrometers, and the scribe of the Mth page on the front face of silicon on sapphire (field which is

equivalent to the side face of a hexagonal prism in hexagonal system) was carried out. The wafer was divided into the chip of 700-micrometer angle after the scribe, and the laser chip of a stripe mold as shown in drawing 5 was produced. In addition, drawing 5 shows the perspective view of the laser component by this example, and makes the nitride semi-conductor stratification plane which intersected perpendicularly with the stripe-like positive electrode the optical resonance side. Moreover, although this laser component has covered the front face except an electrode with the insulator layer which consists of SiO2, especially the insulator layer is not illustrating in drawing 2 and drawing 5 .

[0047] After installing this chip in the heat sink and carrying out wire bond of each electrode, when laser oscillation was tried in ordinary temperature, laser oscillation with an oscillation wavelength of 390nm was checked by threshold current density 1.5 kA/cm2.

[0048] An example 2 is explained based on [example 2] drawing 3 . This also grows up the GaN buffer layer 2 and the Si dope n mold GaN contact layer 3 on silicon on sapphire 1 like an example 1. n mold multilayers 44 which carried out ten layers at a time the laminating of an Si dope n mold In0.01Ga0.95N layer and the Si dope aluminum0.2Ga0.9N layer by turns like the example 1 are formed after contact layer 3 growth.

[0049] Next, second n mold cladding layer 4 which consists of Si dope n mold aluminum0.3Ga0.7N similarly on n mold multilayers 44, First n mold cladding layer 5 which consists of Si dope n mold In0.01Ga0.99N, The barrier layer 6 which consists of non dope n mold In0.05Ga0.95N, first p mold cladding layer 7 which consists of Mg dope p mold In0.01Ga0.99N, and second p mold cladding layer 8 which consists of Mg dope p mold aluminum0.3Ga0.7N are grown up in order, and carries out a laminating.

[0050] Next, make temperature into 800 degrees C, and using TMG, TMI, NH3, and Cp2Mg, grow up a 380A Mg dope p mold In0.01Ga0.95N layer, and temperature is continuously made into 1050 degrees C. Using TMG, TMA, NH3, and Cp2Mg gas, a Mg dope p mold aluminum0.2Ga0.9N layer is grown up by 390A thickness, and p mold multilayers 55 which carried out the laminating ten layers at a time by turns, respectively are formed.

[0051] The wafer into which p mold contact layer 9 which becomes the front face of the p

mold multilayers 55 from the Mg dope p mold GaN was grown up is produced after p mold multilayers 55 formation.

[0052] After making it a chip after etching this wafer similarly, as formed an electrode and shown in drawing 5 , when it considered as the same laser component, similarly laser oscillation with an oscillation wavelength of 390nm was checked by threshold current density 1.0 kA/cm2.

[0053] An example 3 is explained based on [an example 3], next drawing 3 . The GaN buffer layer 2, the Si dope n mold GaN contact layer 3, and the second cladding layer 4 that consists of Si dope n mold aluminum0.3Ga0.7N are grown up on silicon on sapphire 1 like [this] an example 1.

[0054] The second cladding layer 4 and n mold multilayers 44 which the Si dope n mold aluminum0.2Ga0.8N layer was grown up by 400A thickness by continuing, maintaining temperature at 1050 degrees C, growing up an Si dope n mold GaN layer by 390A thickness, and continuing, and carried out the laminating ten layers at a time by turns, respectively are formed.

[0055] Next, first n mold cladding layer 5 which consists of Si dope n mold In0.01Ga0.99N similarly on n mold multilayers 44, the barrier layer 6 which consists of non dope n mold In0.05Ga0.95N, and first p mold cladding layer 7 which consists of Mg dope p mold In0.01Ga0.99N are grown up in order, and carries out a laminating.

[0056] Next, temperature is made into 1050 degrees C, a Mg dope p mold GaN layer is grown up by 390A thickness, and it continues, and a Mg dope p mold aluminum0.2Ga0.8N layer is grown up by 400A thickness, and p mold multilayers 55 which carried out the laminating ten layers at a time by turns, respectively are formed.

[0057] The wafer into which second p mold cladding layer 8 which consists of Mg dope p mold aluminum0.3Ga0.7N similarly, and p mold contact layer 9 which consists of a Mg dope p mold GaN were grown up after p mold multilayers 55 formation is produced.

[0058] After making it a chip after etching this wafer similarly, as formed an electrode and shown in drawing 5 , when it considered as the same laser component, similarly laser oscillation with an oscillation wavelength of 390nm was checked by threshold current density 1.0 kA/cm2.

[0059] The buffer layer which consists of GaN on silicon on sapphire 1 like the [example 4] example 1 is grown up. n mold contact layer 3 which consists of an Si dope n mold GaN is grown up by 4-micrometer thickness after buffer layer growth.

[0060] Next, an Si dope n mold aluminum0.2Ga0.8N layer is grown up by 400A thickness after n mold contact layer 3 growth, and n mold multilayers 44 which the Si dope n mold GaN layer was grown up by 390A thickness, and carried out the laminating ten layers at a time by turns, respectively are formed continuously. However, the last Si dope n mold GaN layer is grown up by 1-micrometer thickness. Thus, n mold multilayers 44 are formed in the interior of n mold contact layer 3.

[0061] The rest produces the wafer which carried out the laminating of second n mold cladding layer 4, first n mold cladding layer 5, a barrier layer 6, first p mold cladding layer 7, second p mold cladding layer 8, and the p mold contact layer 9 to order like the example 1.

[0062] Although this wafer is etched similarly, the etching depth is made deep, and it etches until the 4-micrometer n mold GaN contact layer formed first is exposed. After making it a chip as the rest formed an electrode similarly and shown in drawing 5 , when it considered as the laser component, similarly laser oscillation with an oscillation wavelength of 390nm was checked by threshold current density 1.5 kA/cm2.

[0063] [Example 5] When first n mold cladding layer 5 was not formed and also the laser component was produced like the example 2, laser oscillation with an oscillation wavelength of 390nm was checked by threshold current density 2 kA/cm2.

[0064] [Example 6] When first p mold cladding layer 7 was not formed and also the laser component was produced like the example 2, laser oscillation with an oscillation wavelength of 390nm was checked by threshold current density 1.5 kA/cm2.

[0065] In the [example 7] example 1, in case a barrier layer 6 is grown up, the barrier layer which consists of non dope In0.01Ga0.99N the well layer which consists of non dope In0.05Ga0.95N at 800 degrees C the same 25A and on it is grown up by 50A thickness. This actuation was repeated 13 times, the laminating of the well layer was carried out to the last, and the barrier layer 6 with a total thickness of 1000A was grown up. When considered as the laser component like the example 1, similarly laser oscillation with an

oscillation wavelength of 390nm was checked by the back by 2 the threshold current density of 1.5kA/cm.

[0066]

[Effect of the Invention] As explained above, since the laser component of this invention forms in the location near [horizontal plane / of the etching side nearest to a substrate side] p mold nitride semi-conductor layer the multilayers layer which reflects luminescence of a barrier layer, it cannot miss luminescence to a substrate side, but can perform optical confinement of a barrier layer efficiently. When it follows, for example, the laser of a stripe mold is produced, laser oscillation becomes possible easily.

[0067] Furthermore, if the cladding layer of InGaN is formed in one principal plane side of the barrier layers which consist of InGaN as a desirable mode of this invention, the crystallinity of a barrier layer and the crystallinity of an AlGaN cladding layer will also become good, its crystal defect will decrease, and an oscillation in the ordinary temperature of a laser component and its dependability will improve. In this invention, although the cladding layer which touches a barrier layer has not carried out lattice matching, the effect of this structure is imagined to be size that laser oscillation can be carried out.

[0068] Thus, since it becomes applicable [the write-in light source of a compact disk (CD), the reading light source, the other light sources for a display, the light source for lighting, the light source for vegetable training, etc.] to many devices by the semiconductor laser component of short wavelength having been realizable, the utility value on the industry has a great thing.

[Brief Description of the Drawings]

[Drawing 1] The type section Fig. showing the structure of the conventional 1LED component.

[Drawing 2] The type section Fig. showing the structure of the laser component concerning one example of this invention.

[Drawing 3] The type section Fig. showing the structure of the laser component concerning other examples of this invention.

[Drawing 4] The type section Fig. showing the structure of the laser component concerning

other examples of this invention.

[Drawing 5] The perspective view showing the structure of the laser component concerning one example of this invention.

[Drawing 6] The type section Fig. showing the structure of the laser component concerning other examples of this invention.

[Description of Notations]

1 .... Silicon on sapphire

2 .... Buffer layer

3 .... n mold contact layer

4 .... Second n mold cladding layer

5 .... First n mold cladding layer

6 .... Barrier layer

7 .... First p mold cladding layer

8 .... Second p mold cladding layer

9 .... p mold contact layer

44 ... n mold multilayers

55 ... p mold multilayers